APPENDIX H
DEVELOPMENT OF SITE-SPECIFIC STANDARDS
AOI 10: SUNOCO PHILADELPHIA REFINERY
PHILADELPHIA, PENNSYLVANIA

Based on the current and future intended non-residential site use, an exposure assessment was conducted for all compounds in surficial soil (0-2 feet) which exceeded the nonresidential direct contact statewide health standards in AOI 10. Potential human health exposures for the Refinery are evaluated for an industrial worker scenario.

In AOI 10, soil samples were collected from within the EPA designated Corrective Action Management Unit (CAMU) and around the perimeter the of the CAMU and analyzed for the full suite of VOCs, SVOCs, and Metals; and, samples were collected outside the CAMU designated area and analyzed for the site-specific compounds (as specified in the February 2011 AOI 10 Site Characterization Workplan). To determine if any risk to the industrial worker exist due to direct contact, these samples were compared to the non-residential direct contact medium specific concentrations [PA Code Title 25, Chapter 250.305, Appendix A, Tables 3A and 4A]. Within the CAMU designated area concentrations of benzo(a)pyrene and dibenzo(a,h)anthracene were detected above their respective direct contact MSCs. Outside the CAMU designated area concentrations of arsenic, benzo(a)pyrene, and lead were detected above their respective direct contact MSCs. In accordance with Section IV of the PADEP's Technical Guidance Manual (TGM) (dated June 8, 2002), the COCs listed above were further screened against the EPA Region III Risk-Based Concentrations RBCs (aka, EPA Regional Screening Levels) for industrial soil to potentially reduce the list of compounds carried through the risk assessment; however, the above listed compounds also exceeded Region III's RBCs.

For any compounds that exceed both the non-residential statewide health standards and EPA Region III RBCs, site-specific standards were calculated using PADEP default intake parameters for an on-site worker and, where appropriate, a risk level of 10^{-4}. For calculating a site-specific standard for on-site workers exposed to lead, Sunoco used the Society of Environmental Geochemistry and Health (SEGH) model used by PADEP to

develop the non-residential MSC. The input parameters used to develop the site-specific standards for arsenic [non-carcinogenic and carcinogenic], benzo(a)pyrene, dibenzo(a,h)anthracene and lead are provided in Tables H-1 through H-5.

The calculated site-specific standards are as follows:

Compound	Calculated Site-Specific Standard (mg/kg)
Arsenic [non-carcinogenic / carcinogenic]	8,520 / 529*****
Benzo(a)pyrene	109
Dibenzo(a,h)anthracene	109
Lead	1,708

*******Arsenic has both carcinogenic and non-carcinogenic toxicological effects therefore both criteria were calculated. For characterization the lower, more stringent standard, will be used to screen the analytical data.*

The site-specific screening levels for arsenic, benzo(a)pyrene, and dibenzo(a,h)anthracene were calculated for ingestion based on the calculations specified in 25 Pa. Code § 250.306(b). These calculations used the PADEP's default parameters and an updated target risk level of 1E-4, in consideration of the site-specific conditions (PADEP's default target risk level is 1E-5).

The site-specific screening level for lead was also calculated for ingestion. As presented in 25 Pa. Code § 250.306(e), Appendix A, Table 7, the non-residential soil screening value for lead is based on the method presented in the report 'The Society for Environmental Geochemistry and Health (SEGH) Task Force Approach to the Assessment of Lead in Soil' (Wixson, 1991). The model used by the PADEP and developed by SEGH was also used to calculate the site specific criterion for the refinery. Based on the SEGH model and PADEP's default parameters, PADEP's non-residential direct contact MSC default value for lead in surface soil is 1,000 mg/kg. To develop a site-specific criteria for lead, some of the parameters used by the PADEP were updated in consideration of site-specific conditions and updated lead data collected from recent studies. These parameters are discussed in the following paragraphs.

Target blood lead concentration (T) – The default target blood lead concentration used by the PADEP to develop the non-residential MSC is 20 ug/dL; however, the Center for Disease Control (CDC) recommends that worker blood lead levels be maintained below 25 ug/dL (NIOSH, 2008) to prevent adverse health effects for most workers from exposure to lead throughout a working lifetime. Based on conversations between representatives of Sunoco and EPA, the target lead blood level identified by the CDC is the level used in the site-specific calculations in Tables H-5 and H-6.

Geometric mean background blood lead concentration (B) – B is the background blood lead concentration in the target population from sources other than soil and dust. The PADEP's default value for B is 4 ug/dL and, as summarized in PADEPs reference document (Wixson, 1991), is based on data gathered in the United Kingdom from young children. The US Center for Disease Control and Prevention (CDC) in Atlanta, GA has monitored blood lead levels in US children and adults since 1976 and, based on the most recent results published by the National Center for Environmental Health of the CDC (NCEH, 2005), the mean blood lead concentration for an adult 20 years of age or older is 1.56 ug/dL. Based on the more recent study by the US CDC, the value used for B in the site specific calculation has been revised to 1.56 ug/dL.

CONCLUSIONS

To complete the assessment, the samples collected outside the CAMU were screened separate from the samples collected within the CAMU (Tables H-6 and H-7, respectively). Outside the CAMU, results for arsenic, benzo(a)pyrene, and lead were compared to the calculated site-specific standards. No concentrations of arsenic or benzo(a)pyrene were detected above the site-specific standards; however, concentrations of lead were detected above the site-specific standard in six sample locations. Within the CAMU, results for benzo(a)pyrene and dibenzo(a,h)anthracene were compared to site-specific standards. No concentrations of dibenzo(a,h)anthracene were detected above the site-specific standard; however, a concentration of benzo(a)pyrene was detected above the site-specific standard in one sample location.

In addition to comparing the individual results to the site-specific standards the cumulative risk of exposure to arsenic, benzo(a)pyrene, and dibenzo(a,h)anthracene was also calculated for the samples collected outside and within the CAMU (Tables H-6 and H-7, respectively). Based on the PADEPs TGM, the total cumulative risk for exposure to carcinogenic compounds should not exceed 1E-4 and the cumulative hazard index for exposure to non-carcinogenic compounds should not exceed 1. Lead exposure is dependent on the blood/lead concentration and not risk based; therefore, lead could not be incorporated into the cumulative risk calculation.

As presented in Tables H-6 and H-7:

- The total cumulative hazard index for exposure to the non-carcinogenic compound arsenic is less than the PADEP's requirement of 1.0.
- The total cumulative risk for exposure to carcinogens outside the CAMU is 1.61E-04, is greater than the acceptable limits.
- The total cumulative risk for exposure to carcinogens within the CAMU is 1.83e-04, is greater than the acceptable limits.

References

NCEH (2005). Third National Report on Human Exposure to Environmental Chemicals. Centers for Disease Control and Prevention, National Center for Environmental Health, Division of Laboratory Sciences. Atlanta, Georgia. NCEH. Pub. No. 05-0570.

NIOSH (2008). Adult Blood Lead Epidemiology and Surveillance (ABLES). http://www.cdc.gov/niosh/topics/ABLES

Wixson, B.G., (1991). The Society of Environmental Geochemistry and Health (SEGH) Task Force Approach to the Assessment of Lead in Soil. Trace Substances in Environmental Health. 11-20.

Table H-1
Derivation of Site-Specific Soil Value
for Arsenic (Non-Carcinogenic)[1]
AOI 10 Site Characterization/Remedial Investigation Report
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Parameter	Abbreviation	Assumption	Units	Source
Target Health Quotient	THQ	1		25 Pa. Code § 250.306(d)
Oral Reference Dose	RfD_o	0.003	$mg/kg\text{-}day^{-1}$	25 Pa. Code § 250, Appendix A Table 5
Body Weight	BW	70	kg	25 Pa. Code § 250.306(d)
Averaging Time	AT_{DC}	25	yr	25 Pa. Code § 250.306(d)
Absorption	Abs	1	unitless	25 Pa. Code § 250.306(d)
Exposure Frequency	EF	180	d/yr	25 Pa. Code § 250.306(d)
Exposure Duration	ED	25	yr	25 Pa. Code § 250.306(d)
Conversion Factor	CF	1.00E-06	kg/day	25 Pa. Code § 250.306(d)
Ingestion Rate	IngR	50	mg/day	25 Pa. Code § 250.306(d)

Site-Specific, Non-Residential (Onsite Worker) Screening Value	**8,520**	**mg/kg**

Notes:

1. The site specific screening value was calculated for ingestion based on the calculation specified in 25 Pa. Code 250.306(b)

$$MSC\ (mg/kg) = \frac{THQ \times RFDo \times BW \times AT_{DC} \times 365\ days/year}{Abs \times EF \times ED \times IngR \times CF}$$

Table H-2
Derivation of Site-Specific Soil Value
for Arsenic (Carcinogenic)[1]
AOI 10 Site Characterization/Remedial Investigation Report
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Parameter	Abbreviation	Assumption	Units	Source
Absorption	ABS	1	unitless	25 Pa. Code § 250.306(d)
Exposure Frequency	EF	180	d/yr	25 Pa. Code § 250.306(d)
Conversion Factor	CF	1.00E-06	kg/day	25 Pa. Code § 250.306(d)
Target Risk[2]	TR	1.00E-04	mg/kg	
Oral Cancer Slope Factor	CSF_o	1.5	$mg/kg\text{-}day^{-1}$	25 Pa. Code § 250, Appendix A Table 5
Averaging Time for Carcinogens	AT_c	70	yr	25 Pa. Code § 250.306(d)
Ingestion Factor	IFadj	17.9	mg-yr/kg-day	25 Pa. Code § 250.306(d)

Site-Specific, Non-Residential (Onsite Worker) Screening Value **529** **mg/kg**

Notes:

1. The site specific screening value was calculated for ingestion based on the calculation specified in 25 Pa. Code 250.306(b)

$$MSC\ (mg/kg) = \frac{TR \times AT_C \times 365\ days/year}{CSF_O \times Abs \times EF \times IF_{ADJ} \times CF}$$

2. The target risk level was modified from PADEP's default (1E-5) to 1E-4.

Table H-3
Derivation of Site-Specific Soil Value
for Benzo(a)pyrene[1]
AOI 10 Site Characterization/Remedial Investigation Report
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Parameter	Abbreviation	Assumption	Units	Source
Absorption	ABS	1	unitless	25 Pa. Code § 250.306(d)
Exposure Frequency	EF	180	d/yr	25 Pa. Code § 250.306(d)
Conversion Factor	CF	1.00E-06	kg/day	25 Pa. Code § 250.306(d)
Target Risk[2]	TR	1.00E-04	mg/kg	
Oral Cancer Slope Factor	CSF_o	7.3	$mg/kg\text{-}day^{-1}$	25 Pa. Code § 250, Appendix A Table 5
Averaging Time for Carcinogens	AT_c	70	yr	25 Pa. Code § 250.306(d)
Ingestion Factor	IFadj	17.9	mg-yr/kg-day	25 Pa. Code § 250.306(d)

Site-Specific, Non-Residential (Onsite Worker) Screening Value **109** **mg/kg**

Notes:

1. The site specific screening value was calculated for ingestion based on the calculation specified in 25 Pa. Code 250.306(b)

$$MSC\ (mg/kg) = \frac{TR \times AT_C \times 365\ days/year}{CSF_O \times Abs \times EF \times IF_{ADJ} \times CF}$$

2. The target risk level was modified from PADEP's default (1E-5) to 1E-4.

Table H-4
Derivation of Site-Specific Soil Value
for Dibenzo(a,h)anthracene[1]
AOI 10 Site Characterization/Remedial Investigation Report
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Parameter	Abbreviation	Assumption	Units	Source
Absorption	ABS	1	unitless	25 Pa. Code § 250.306(d)
Exposure Frequency	EF	180	d/yr	25 Pa. Code § 250.306(d)
Conversion Factor	CF	1.00E-06	kg/day	25 Pa. Code § 250.306(d)
Target Risk[2]	TR	1.00E-04	mg/kg	
Oral Cancer Slope Factor	CSF_o	7.3	$mg/kg\text{-}day^{-1}$	25 Pa. Code § 250, Appendix A Table 5
Averaging Time for Carcinogens	AT_c	70	yr	25 Pa. Code § 250.306(d)
Ingestion Factor	IFadj	17.9	mg-yr/kg-day	25 Pa. Code § 250.306(d)

Site-Specific, Non-Residential (Onsite Worker) Screening Value **109** **mg/kg**

Notes:

1. The site specific screening value was calculated for ingestion based on the calculation specified in 25 Pa. Code 250.306(b)

$$MSC\ (mg/kg) = \frac{TR \times AT_C \times 365\ days/year}{CSF_O \times Abs \times EF \times IF_{ADJ} \times CF}$$

2. The target risk level was modified from PADEP's default (1E-5) to 1E-4.

Table H-5
Derivation of Site-Specific Soil Value
for Lead[1]
AOI 10 Site Characterization/Remedial Investigation Report
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Parameter	Abbreviation	Assumption	Units	Source[2]
Blood lead target concentration	T	25	ug/dL	CDC - ABLES (NIOSH, 2008)
Geometric standard deviation of the blood lead distribution	G	1.4	unitless	25 Pa. Code § 250, Appendix A Table 7
Background blood lead concentration in the population from sources other than soil or dust	B	1.56	ug/dL	NCEH Pub. No. 05-0570 (NCEH, 2005)
Number of standard deviations corresponding to the degree of protection required for the population at risk	n	1.645	unitless	25 Pa. Code § 250, Appendix A Table 7
Response of the blood lead versus soil lead relationship	δ	7.5	ug/dL blood / ug/g soil	25 Pa. Code § 250, Appendix A Table 7

Site-Specific, Non-Residential (Onsite Worker) Screening Value **1,708** **ug/g (mg/kg)**

Notes:

1. The site specific screening value for lead was calculated for ingestion based on the SEGH model as specified by 25 Pa. Code 250.306(e)

$$MSC\ (mg/kg) = \frac{[(T/G^{n}) - B] \times 1000}{\delta}$$

2. Sources for blood lead target level (T) based on conversation between James Oppenheim of Sunoco and Hon Lee of EPA in November 2010.

NIOSH (2008). Adult Blood Lead Epidemiology and Surveillance (ABLES). http://www.cdc.gov/niosh/topics/ABLES

NCEH (2005). Third National Report on Human Exposure to Environmental Chemicals. Centers for Disease Control and Prevention, National Center for Environmental Health, Division of Laboratory Sciences. Atlanta, Georgia. NCEH. Pub. No. 05-0570.

Table H-6
Site Specific Cumulative Risk Evaluation for the Area Outside of the Corrective Action Management Unit (CAMU)
AOI 10 Site Characterization/Remedial Investigaiton Report
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

				Arsenic (7440-38-2)		Arsenic (7440-38-2)		Benzo(a)pyrene (50-32-8)		Lead (7439-92-1)	
Location ID	Sample ID	Sample Interval	Sample Date	Reported Result (mg/kg)	Calculated Hazard Quotient	Reported Result (mg/kg)	Calculated Risk	Reported Result (mg/kg)	Calculated Risk	Reported Result (mg/kg)	Blood Lead Concentration[5] (ug/dL)
BH-10-36	BH-10-36_0-2'	0-2	4/5/2011	NA	--	NA	--	1.8	1.66E-06	390	8
BH-10-37	BH-10-37_0-2'	0-2	4/5/2011	NA	--	NA	--	6.5	5.98E-06	540	10
BH-10-38	BH-10-38_0-2'	0-2	4/5/2011	NA	--	NA	--	ND	--	11.6	3
BH-10-39	BH-10-39_0-2'	0-2	4/5/2011	NA	--	NA	--	16	1.47E-05	415	8
BH-10-40	BH-10-40_0-2'	0-2	4/5/2011	NA	--	NA	--	9.2	8.47E-06	65.1	4
BH-10-41	BH-10-41_0-2'	0-2	4/5/2011	NA	--	NA	--	ND	--	186	5
BH-10-42	BH-10-42_0-2'	0-2	4/19/2011	NA	--	NA	--	1.3	1.20E-06	249	6
BH-10-47	BH-10-47_0-2'	0-2	4/19/2011	NA	--	NA	--	0.82	7.55E-07	233	6
BH-10-49	BH-10-49_0-2'	0-2	4/19/2011	NA	--	NA	--	0.14	1.29E-07	340	7
BH-10-50	BH-10-50_0-2'	0-2	4/19/2011	NA	--	NA	--	1.3	1.20E-06	84.7	4
BH-10-53	BH-10-53_0-2'	0-2	4/22/2011	NA	--	NA	--	0.39	3.59E-07	3310	**46**
BH-10-54	BH-10-54_0-2'	0-2	4/22/2011	NA	--	NA	--	2.5	2.30E-06	186	5
BH-10-59	BH-10-59_0-2'	0-2	4/22/2011	NA	--	NA	--	1.6	1.47E-06	401	8
BH-10-60	BH-10-60_0-2'	0-2	4/22/2011	NA	--	NA	--	10	9.21E-06	777	13
BH-10-61	BH-10-61_0-2'	0-2	4/22/2011	NA	--	NA	--	0.58	5.34E-07	118	4
BH-10-62	BH-10-62_0-2'	0-2	4/22/2011	NA	--	NA	--	2.4	2.21E-06	2580	**36**
BH-10-66	BH-10-66_0-2'	0-2	4/21/2011	NA	--	NA	--	0.065	5.98E-08	250	6
BH-10-67	BH-10-67_0-2'	0-2	4/21/2011	NA	--	NA	--	0.57	5.25E-07	985	16
BH-10-71	BH-10-71_0-2'	0-2	4/5/2011	NA	--	NA	--	0.51	4.69E-07	244	6
BH-10-72	BH-10-72_0-2'	0-2	4/5/2011	NA	--	NA	--	49	4.51E-05	946	15
BH-10-73	BH-10-73_0-2'	0-2	4/5/2011	NA	--	NA	--	ND	--	4550	**62**
BH-10-76	BH-10-76_0-2'	0-2	4/20/2011	NA	--	NA	--	1.8	1.66E-06	1990	**29**
BH-10-78	BH-10-78_0-2'	0-2	4/21/2011	NA	--	NA	--	0.66	6.08E-07	79.3	4
BH-10-79	BH-10-79_0-2'	0-2	4/21/2011	NA	--	NA	--	0.046	4.23E-08	145	5
BH-10-80	BH-10-80_0-2'	0-2	4/21/2011	NA	--	NA	--	1.4	1.29E-06	234	6
W-1D	W-1D_0-2'	0-2	4/5/2011	NA	--	NA	--	2.7	2.49E-06	76.5	4
W-28	W-28_0-2'	0-2	4/19/2011	NA	--	NA	--	0.39	3.59E-07	181	5
W-29	W-29_0-2'	0-2	4/19/2011	NA	--	NA	--	0.84	7.73E-07	259	6
W-30	W-30@0'-2'	0-2	4/15/2011	NA	--	NA	--	ND	--	1990	**29**
W-31	W-31@0'-2'	0-2	4/15/2011	NA	--	NA	--	0.59	5.43E-07	955	15
W-32D	W-32D_0-2'	0-2	4/7/2011	NA	--	NA	--	0.43	3.96E-07	1200	18
W-33	W-33_0-2'	0-2	4/20/2011	NA	--	NA	--	0.2	1.84E-07	297	7
W-34	W-34_0-2'	0-2	4/20/2011	NA	--	NA	--	0.54	4.97E-07	561	10
BH-10-43	BH-10-43_0-2'	0-2	4/14/2011	14.7	0.002	14.7	2.78E-06	ND	--	167	5
BH-10-48	BH-10-48_0-2'	0-2	4/14/2011	20	0.002	20	3.78E-06	0.42	3.87E-07	278	6
BH-10-51	BH-10-51_0-2'	0-2	4/14/2011	21.3	0.003	21.3	4.03E-06	0.45	4.14E-07	1720	**25**
BH-10-52	BH-10-52_0-2'	0-2	4/14/2011	12.2	0.001	12.2	2.31E-06	0.59	5.43E-07	1480	22
BH-10-57	BH-10-57_0-2'	0-2	4/21/2011	21.1	0.002	21.1	3.99E-06	ND	--	743	12
BH-10-58	BH-10-58_0-2'	0-2	4/14/2011	18.6	0.002	18.6	3.52E-06	ND	--	941	15
BH-10-65	BH-10-65_0-2'	0-2	4/14/2011	8.71	0.001	8.71	1.65E-06	ND	--	307	7
BH-10-68	BH-10-68_0-2'	0-2	4/14/2011	7.99	0.001	7.99	1.51E-06	ND	--	94.2	4
BH-10-75	BH-10-75_0-2'	0-2	4/19/2011	61.3	0.007	61.3	1.16E-05	2.8	2.58E-06	192	5
BH-10-81	BH-10-81_0-2'	0-2	4/21/2011	38.9	0.005	38.9	7.36E-06	2.7	2.49E-06	242	6
BH-10-82	BH-10-82_0-2'	0-2	4/20/2011	17	0.002	17	3.22E-06	0.96	8.84E-07	584	10
BH-10-83	BH-10-83_0-2'	0-2	4/21/2011	13.7	0.002	13.7	2.59E-06	0.68	6.26E-07	402	8
			Cumulative Total:		***0.030***		***4.83E-05***		***1.13E-04***		

Maximum Total Cumulative Risk for Carcinogens: **1.61E-04** *> 1 in 10,000*
Maximum Hazard Index for Non-Carcinogens: **0.03000** *< 1*

Notes:
ND - Not Detected Above Lab Reporting Limit
NA - Arsenic is not a site-specific compound and therefore not analyzed on a site-wide basis.
(1) All soil samples collected and analyzed were unsaturated.
(2) All samples are located outside SWMU/CAMU areas.
(3) Maximum Total Cumulative Risk is the combined risk of exposure to the detected concentrations of carcinogenic compounds arsenic and BaP and should be less than 1 in 10,000.
(4) Maximum Hazard Index is the combined risk of exposure to the detected concentrations of the non-carcinogenic compound arsenic and should be less than 1.
(5) Calculated based on site specific parameters provided in Table F-4. The CDC (NIOSH, 2008) recommends that blood lead levels be maintained below 25 ug/dL.

Table H-7
Site Specific Cumulative Risk Evaluation for the Corrective Action Management Unit (CAMU)
AOI 10 Site Characterization/Remedial Investigaiton Report
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

				Benzo(a)pyrene (50-32-8)		Dibenzo(a,h)anthracene (53-70-3)	
Location ID	Sample ID	Sample Interval	Sample Date	Reported Result (mg/kg)	Calculated Risk	Reported Result (mg/kg)	Calculated Risk
BH-10-44	BH-10-44-WC_0-2'	0-2	40645	0.18	1.66E-07	ND	--
BH-10-45	BH-10-45-WC_0-2'	0-2	40645	ND	--	ND	--
BH-10-46	BH-10-46-WC_0-2'	0-2	40645	ND	--	ND	--
BH-10-55	BH-10-55-WC_0-2'	0-2	40645	0.82	7.55E-07	0.29	2.67E-07
BH-10-56	BH-10-56-WC_0-2'	0-2	40645	1.6	1.47E-06	0.52	4.79E-07
BH-10-63	BH-10-63-WC_0-2'	0-2	40646	ND	--	ND	--
BH-10-64	BH-10-64-WC_0-2'	0-2	40646	120	**1.10E-04**	73	6.72E-05
BH-10-69	BH-10-69-WC_0-2'	0-2	40645	ND		ND	--
BH-10-70	BH-10-70-WC@0'-2'	0-2	40644	ND	--	ND	--
BH-10-77	BH-10-77-WC_0-2'	0-2	40646	1.9	1.75E-06	0.53	4.88E-07
			Cumulative Total:		***1.15E-04***		***6.84E-05***

Maximum Total Cumulative Risk for Carcinogens: **1.83E-04** *> 1 in 10,000*

Notes:
ND - Not Detected Above Lab Reporting Limit
(1) All soil samples collected and analyzed were unsaturated.
(2) All samples are located inside CAMU areas.
(3) Maximum Total Cumulative Risk is the combined risk of exposure to the detected concentrations of carcinogenic compounds BaP and dibenzo(a,h)anthracene and should be less than 1 in 10,000.